

-continued

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What is claimed is:

1. A vaccine comprising an attenuated live bacterial or viral cell comprising a non-natural amino acid site-specifically incorporated into an essential gene product required for replication, wherein said cell is capable of replication in the presence of said non-natural amino acid, and has limited or no replication capability in the absence of said non-natural amino acid; and wherein the vaccine induces an immune response or reduces the risk of a bacterial or viral infection to said cell.

2. The vaccine of claim 1, wherein the cell is an *E. coli* cell, a bacterial cell or a *Mycobacterium avium* subspecies paratuberculosis (MAP) cell.

3. The vaccine of claim 1, further comprising a pharmaceutically acceptable excipient.

4. The vaccine of claim 1, wherein the essential gene product required for replication is selected from the group consisting of ileS, lspA, ispH, ftsL, ftsI, murE, murD, ftsW, murG, murC, ftsQ, ftsA, ftsZ, secA, map, rpsB, pyrH, frr, uppS, cdsA, fabZ, lpxA, lpxB, dnaE, accA, proS, nusB, dxs, ispA, dnaX, adk, cysS, mrdB, mrdA, holA, leuS, glnS, serS, msbA, kdsB, asnS, fabA, rne, fabD, fabG, tmk, holB, lolC, lolD, lolE, trmU, prsA, topA, fabI, pheS, rplT, infC, nadE, aspS, argS, rplY, nrdA, nrdB, fabB, gltX, ligA, zipA, yfgE, hisS, acpS, rplS, trmD, rpsP, ffh, grpE, plsC, parC, parE, ribB, rpoD, rpsO, yhbZ, rpsI, rplM, def, rpsM, secY, rplO, rpsE, rplR, rplF, rpsN, rplIX, rplN, rpsQ, rpsS, rplB, rplW, rplD, rplC, rpsJ, fusA, rpsL, trpS, ftsY, glyS, kdtA, coad, dut, gmk, dnaA, glmU, engB, murl, rplJ, rplL, rpoB, rpoC, dnaB, groS, groL, efp, rpsf, ppa, valS, dnaC, and dnaT.

5. The vaccine of claim 1, wherein the non-natural amino acid is selected from the group consisting of para-acetylphenylalanine, p-nitrophenylalanine, p-sulfotyrosine, p-carboxyphenylalanine, o-nitrophenylalanine, m-nitrophenylalanine, p-boronyl phenylalanine, o-boronylphenylalanine, m-boronylphenylalanine, p-aminophenylalanine, o-amino-phenylalanine, m-aminophenylalanine, p-acylphenylalanine, o-acylphenylalanine, m-acylphenylalanine, p-OMe phenylalanine, o-OMe phenylalanine, m-OMe phenylalanine, p-sulfophenylalanine, o-sulfophenylalanine, m-sulfo-phenylalanine, 5-nitro His, 3-nitro Tyr, 2-nitro Tyr, a nitro substituted Leu, a nitro substituted His, a nitro substituted De, a nitro substituted Trp, 2-nitro Trp, 4-nitro Trp, 5-nitro Trp, 6-nitro Trp, 7-nitro Trp, 3-aminotyrosine, 2-aminotyrosine, O-sulfotyrosine, 2-sulfoxyphenylalanine, 3-sulfooxyphenylalanine, p-carboxyphenylalanine, o-carboxyphenylalanine, m-carboxyphenylalanine, p-acetyl-L-phenylalanine, p-propargyl-phenylalanine, O-methyl-L-tyrosine, L-3-(2-naphthyl)alanine, 3-methyl-phenylalanine, O-4-allyl-L-tyrosine, 4-propyl-L-tyrosine, tri-O-acetyl-GlcNAc beta.-serine, an L-Dopa, a fluorinated phenylalanine, isopropyl-L-phenylalanine, p-azido-L-phenylalanine, p-acyl-L-phenylalanine, p-benzoyl-L-phenylalanine, L-phosphoserine, phosphonoserine, phosphonotyrosine, p-iodo-phenylalanine, p-bromophenylalanine, p-amino-L-phenylalanine, isopropyl-L-phenylalanine, and p-propargyloxyphenylalanine.

6. The vaccine of claim 1, wherein more than one non-natural amino acid is incorporated into the essential gene product for replication.

7. The vaccine of claim 1, wherein more than one non-natural amino acid is incorporated into more than one essential gene product for replication.

8. The vaccine of claim 7, wherein the non-natural amino acid is para-acetylphenylalanine.

9. The vaccine of claim 1, wherein the essential gene product required for replication is methionine amino peptidase (map).

10. A method of inducing an immune response or reducing the risk of a bacterial or viral infection, the method comprising administering to a patient an effective amount of the vaccine of claim 1.

11. The method of claim 10, wherein the patient is a human.

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